

Using Visualization and Pedagogical Patterns in Support of Undergraduate Students with Autism Spectrum Disorders

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Abstract

Undergraduate students with autism spectrum disorders (ASD), who are overrepresented on IT degree programs, experience significant and unique challenges that require specific interventions and support mechanisms. Research on university students with ASD shows mixed results; for many, there is a poor outcome. There is therefore a general need for reports on educational practices and insight from professionals who work closely with these students. Practical support (extended deadlines, a quiet working space) is provided according to well-known recommendations for these students, but pedagogical interventions, which are equally important, are often lacking. This paper describes the professional supervision of undergraduate IT students diagnosed with ASD over a period of several years. The diversity of people with ASD makes it necessary to target each student individually, in order to apply effective methods. Some traits are, however, broadly common to this population, and when correctly identified, pedagogical patterns can be applied to successfully address some of the challenges these students face. As an alternative to (often excessive) verbal explanations, we report how modelling techniques can be used to both explain and visualize practical problems related to subjects like programming and databases. The positive outcomes of this approach are confirmed through interviews, observations of the students and academic results.

Key words: Autism spectrum disorders, ASD, undergraduate students, visualization, pedagogical patterns.

Introduction

Autism spectrum disorder (ASD) is a developmental disorder that causes difficulties with socializing, communication and behaviour. Social awkwardness, lack of understanding of social context, hypersensitivity, anxiety and depression stemming from a sense of overwhelming chaotic surroundings and loneliness are common. The term "spectrum" indicates that some people have a few mild symptoms while others have severe symptoms that are disabling.

The author of this paper is a computer scientist with over ten years of experience supervising students on the autistic spectrum, many also with ADHD, a common comorbidity. The increase in students who need support is evident. A decade ago, the numbers were scarce, either due to lack of a diagnosis or little awareness about the existence of these students. Since then, the author has acquired substantial experience in the field and worked systematically in order to create methods for better learning experiences in a safe environment. There are currently six known students in IT studies at Oslo Metropolitan University (OsloMet), approximately one percent of the student mass. There are probably several more who have not been identified, or who do not wish support. Five students have completed their studies and are currently holding permanent jobs or continuing studies on master programs in IT. This paper aims both to add to the experience and literature in the field, and to provide insight and recommendations for teachers who have a student with ASD on their course.

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Background

Several types of interventions exist for students with ASD, but research indicates that not all are effective. According to a recent study, several drop out of studies or achieve poor academic results (Gelbar et al., 2014). These students face a number of challenges. Comorbidity: multiple diagnoses like ADHD, psychological distress in the form of anxiety and depression, aggression, poor social and interpersonal skills and cognitive deficits present problems that must be addressed by support programs and professionals who are in daily contact with the students (Billstedt et al., 2005). Not only are the surroundings on campus perceived as chaotic, tasks and assignments can be overwhelming. There is generally not much knowledge about ASD amongst teachers and peers, therefore little understanding of social problems, learning difficulties and practical challenges. The diversity of these students makes it difficult to find one approach that will work for all, so there is a need to identify methods and interventions that can be used effectively for the individual. Henninger & Taylor also show how teachers' skills and values as well as institutional resources can affect how intervention is devised, and whether it is applied effectively (2013).

The number of children diagnosed with ASD in the United States and other countries has increased since the 1970s and particularly since the late 1990s. More awareness and changes in the definition of ASD account for much of the increase. Between 2 and 20 children per 1000 are diagnosed with ASD. Centers for Disease Control and Prevention (CDC) report a prevalence of 1 in 80, and it affects approximately four times as many boys as girls (2014). However, many young people and adults have been given the diagnosis late or not at all, and recent research has uncovered that several girls who are diagnosed with anorexia have ASD, as eating disorders are common, so the figures denoting prevalence vary (Dudova et al., 2015).

Many people with ASD are visual thinkers, but not all. Some are verbal thinkers, others mathematical thinkers and pattern thinkers (Grandin, T., 2006). Baron-Cohen has shown how mathematical skills are linked to autism in a study confirming a link between autism and systemizing (2014). All people with autism have a great focus on detail. It is therefore worth exploring visualization and modelling as pedagogical methods where well-known techniques are tailored to address academic problems and difficult social situations.

Students with ASD have specific learning problems, and some have behaviour that is perceived as problematic when amongst other people. When deciding what kind of intervention should be applied in a given situation, it is not always necessary to devise a special technique or method for each individual. The findings in this study show that there are certain common challenges, this indicates that it can be useful to apply specific methods, or pedagogical patterns, to help with these challenges.

Pedagogical patterns are high-level patterns that have been recognized in many areas of training and pedagogy. The patterns seek to foster best practices of teaching. Pattern techniques were originally described as an architectural design technique by Christopher Alexander, a buildings architect (1979). Later, software developers adapted patterns as a reusable design tool (Gamma et al., 1994).

Although widespread in the software industry, the use of patterns is still emerging in the educational field. Joseph Bergin has conducted workshops developing fourteen pedagogical patterns for computer science course development. *“The intent (of pedagogical patterns) is to capture the essence of the practice in a compact form that can be easily communicated to those who need the knowledge. Presenting this information in a coherent and accessible form can mean the difference between every new instructor*

needing to relearn what is known by senior faculty and easy transference of knowledge of teaching within the community“ (2000-2006).

Intervention Strategies

There is no single approach that can meet all the needs of students with ASD. But needs are not entirely determined by individual behaviour. It is the understanding of ASD that enables the teacher to correctly identify learning needs and to address them. Teaching practices should be based on evidence of effectiveness. Gelbar et al. conducted a systematic review on intervention for college students with ASD, and identified and examined eight programs (2014). The findings regarding results and effect were mixed. Sample sizes are a challenge, often being limited (Kuder et al. 2018). The population of students with ASD in each institution is small. Even with 2 or 3 percent students with ASD on a program, this will only constitute 10-12 individuals. Many students are unwilling to participate in experiments or interviews, either because it is perceived as terrifying or uncomfortable, or out of fear of being identified.

People with ASD differ between themselves more than the neurotypical population. The term “neurotypical” defines people with normal cognition, as opposed to people with varying degrees of autism. VanBergeijk et. al describe how neurotypical students may benefit from a variety of counselling modalities, while students on the autism spectrum require directive, explicit guidance (2008). Results also depend on personal trust and communication. Research on intervention for people with intellectual disabilities shows that it is essential to form an emotional connection between teacher/carer and student (Singh et al., 2016). Reports on adults with ASD show that they experience an easier life as they grow older, but that a majority have had suicidal thoughts when young (Kittelsaa, A.M., 2000). Information about ASD is therefore important in order to give adequate support with distress and loneliness.

Intervention can be divided into two categories: Practical support and pedagogical intervention methods. Practical strategies include extra time for exams and extended deadlines for assignments, a secluded working space, and alternatives to group projects and assignments involving public speaking (Scmulsky & Gobbo, 2013). Universell has published useful guidelines for supporting students with ADHD and ASD (Universell.no, 2012). To address the hypersensitivities that are common to many students with ASD, elimination of as many distracting environmental stimuli as possible is important. Typical are: sounds, smell, and visual stimuli.

Learning difficulties faced by individuals with ASD can be addressed by using pedagogical methods and a variety of instructional strategies including breaking tasks into smaller pieces, providing clear expectations for submitted work, making study plans and organizing the work. The skills, understandings, and decision making of practitioners is crucial (VanBergeijk et al., 2008). Difficulties with loosely structured courses and abstract language used by peers and professors have been addressed by providing detailed syllabi and using concrete language in lectures. People with ASD interpret the spoken and written word literally. Instructors must avoid misunderstandings caused by the use of metaphors, synonyms and homonyms (Ribu, K., 2012). Further, taking a reduced course load is often recommended.

Teachers should base their intervention practices on scientific evidence of efficacy. Research literature can provide the source for identifying pedagogical methods that generate positive outcomes for people with ASD. But most of the literature describes support and treatment for children and youths. There are intervention programs for young adults transitioning to university and college, and there are recommendations for mentoring programs. What is lacking are reports on effective pedagogical interventions

provided by teachers. The study described in this paper is a contribution to the literature and practice in the field.

Methods

The intervention strategies presented in this paper have been derived from literature, practice, experience, open and semi-structured interviews with students. The sample size is small, as is not uncommon in qualitative studies in pedagogy (Torrence H., 2010).

The author gives supervision on an individual basis. Some students require weekly consultations in the form of long or short meetings, others have a peer mentor with whom they meet once or twice a week. Some need a meeting once a month. In order to get acquainted with each student, their first individual meeting starts with a short semi-structured interview with follow-up questions about living conditions, interests, ailments and family relations. The results of these interviews are not included in the data collection, but are merely used to map needs and preferences in order to define which pedagogical methods and approaches may work for the specific student. Depending on responses and willingness to talk, questions are followed up and a conversation can develop. The goal is to get to know the students, their strengths and weaknesses, and to understand their work capacity so that a structured plan can be set up.

For data collection, open interviews were later conducted with eight students. For this group, open interviews give the best result (Kittelsaa, A.M., 2000). The interviews were quite short, with a maximum of thirty minutes duration, as some students experience stress and concentration problems. Three students were interviewed more than once, due to fatigue and loss of concentration.

From the open interviews, conversations and observations, the following research questions were formed:

1. Can visualization and the use of UML modelling techniques (also modified) be an effective method in interpreting and explaining problems to the students?
2. Can pedagogical patterns inspired by software design patterns be used as a tool to demonstrate how to plan and structure work, and modify or change rigid behaviour?

Common Challenges

From the open interviews, some common challenges were defined. Three students have serious problems related to speech and conversation, they could not be interviewed as an interview situation is too stressful. They were observed in work, and there were short informal conversations.

One student reported when asked how he felt after the interview:

“I am exhausted, because I have read all the titles of all your books in the bookshelves twice while we have been talking.”

Three students complemented the interviews with written statements in emails and Facebook Messenger. They experienced writing as less stressful than talking. In writing, they showed advanced verbal skills and expressed their thoughts better than in the interview situation.

In addition, a 55 years old adult who was diagnosed late in life has been interviewed twice, and has given valuable information. Teachers on the basic IT courses have been approached informally and asked if they know of any students with ASD in their class, and if they have any pedagogical experience with such students.

Certain problematic situations recurred, for instance solving programming tasks. One student described her frustration:

“I cannot understand what I am doing wrong. I see the code in my head, but I start programming, and then it gets all muddled. I start again from the beginning, but it doesn’t work out right. This is the third time I try from scratch, my compulsory assignment is still not approved. I don’t understand the answer I get from the teacher. What shall I do? “

The solution was to make sketches and visualize the result, break the task down into smaller parts, sketch each part with boxes, arrows and input fields on sheets of paper. A digital diagram of how to split the task up visualized the work flow. After the session the student asked if she could take the sketches.

“Then I will remember what we talked about and what I have to do.”

A couple of days later the assignment was completed.

Exams and the exam surroundings can be extremely stressful. Sitting in a room full of people, or by oneself in an unknown place and maybe not understanding the texts can lead to unnecessary failure. One student sat in a room by himself, but was disturbed by the tram running outside the window. He was so stressed that he could not communicate the problem to the supervising teacher.

“I could not do anything, the tram made such a dreadful noise”.

He failed the exam, although he would not have had any trouble if the surroundings had been quiet. Nobody had thought about the disturbing traffic.

A second student who has good academic results and works independently experiences anxiety and stress about getting to the exam rooms. His parents have taken him by car and waited for him to settle, and picked him up afterwards. This has not been communicated to the institution until lately. In the open interview he said:

“I am fine, I don’t need any help, but I can talk to you if you want.”

This is not uncommon. The student wishes to appear “normal”, and achieve good results with no help. It is therefore important to meet with the student from time to time to make sure that there really are no obstacles or problems.

One of the students yielded the following information, showing how his pattern thinking can be an obstacle, but also a solution, and how he applies self-management strategies:

“I see patterns. For instance, I see the calendar as three rows of four months.

No other representation makes any sense to me. I get angry if somebody tries to convince me otherwise.”

“I also have a lot of rigid behaviour. I force myself to change behaviour and obsessions by doing things in a different order, like running in the opposite direction on my training route.»

This is valuable information; it shows that it is possible to change obsessive thinking. One student has a rigid approach to problem solving. In mathematics, he had help from a peer mentor. He did not give an interview, but was observed. His problem was that task number two could not be commenced before task number one had been completed. He did not make any way ahead, and the deadline was drawing close, causing great stress. The student mentor could not convince him that it was not important in which order the tasks were solved.

The author decided to try a visual strategy to approach the problem of rigidity, and drew a diagram of an alternative work-path to the goal; a complete set of answers and a grade. Task 1, 2 and 3 with a), b) c) etc. was shown alternatively as 2, 3, 1 with c), a) b) leading to the same goal. A small program in pseudocode was also written to show that the end-result would be the same even if the order was different. These techniques proved

to be effective, the student relaxed after some time, and with gentle persuasion completed the assignment.

Situations arise where the student experiences anxiety because of unforeseen things that happen, or there are sudden changes to the program. This is common amongst people with ASD. They need to be prepared. Otherwise, a change of plans causes stress, anger and anxiety.

Student: *“There was suddenly a forty minute break in the lecture, I did not know what to do. I panicked and went home. “*

Student: *“If there is a sudden change of plans I get very angry and confused. I refuse to go along with it. For instance if my parents decide to go on a week-end trip and they haven’t informed me until the last day, or the lecture is in a different room”.*

The open interviews also yielded information on how many have used self-management skills to learn social interaction:

Student: *“I have feelings, I just do not know how to handle them. I ask my friends what their face expressions mean, and they explain.”*

Student: *“I have taught myself social skills the way I learn mathematics. “*

Adult 55 years old: *« You have to get to know yourself. You will not get rid of your problems, but more awareness of self will make your life easier, and for those around you. I have used my cognition and developed strategies to appear normal to my surroundings. I still have many quirks and sometimes strange behaviour, but I am not depressed or anxious like I was when younger. I have also studied myself in the mirror to rid myself of the typical stiff and ungainly Asperger movements.”*

A former student identified the stressfulness of exams and presented a solution that might benefit all students:

“Why not have digital exams where you drag and drop icons – like on the phone – and pick a certain number of tasks, for instance 15 out of 20. This would be a familiar situation, and could reduce stress. And maybe be a good way to do it for all students.”

Natural speech can be confusing to people with ASD. Half-sentences and contradictions can be difficult or impossible to understand. Lecturers and instructors sometimes speak in a way that can be difficult to follow, with lengthy explanations, digressions and metaphors. Listening to a lecturer for 2x45 minutes can be confusing and tiring.

In a situation where a third person was testing and commenting on a programming task, the student asked the author:

“Could you please translate what he is saying into my language?”

The language she meant was clear speech with no abstractions or digressions. This student also reported:

“What helps me most is having these weekly meetings with you, when you explain things to me.”

Information gathered from the interviews also shows the importance of the personal contact with an instructor who has the appropriate knowledge and skills.

Former student reported:

“What helped me most was relating to you as a teacher, you knew a lot about Asperger’s”.

Former student, now master student:

“It was as if you put me on the railway-track, gave me a push and made sure I stayed there. “

Design of Intervention

From the interviews and observations, the following ten common problems have been identified.

The student:

1. does not understand the assignment text
2. commences a task (i.e. programming) without preparation or planning
3. has problems understanding the lecturer or instructor
4. is obsessed with detail, fails to see the big picture
5. has a rigid approach to problem solving, i.e. order of tasks
6. is afraid of attending class, does not participate in lectures or exercises
7. fails to hand in mandatory assignments, or does not attend exams and fails.
8. experiences stress in exam situations
9. is anxious and confused amongst other students. Social interaction is difficult
10. talks incessantly and loudly, disturbing the class

In order to address these specific challenges, two intervention strategies have been designed and tested: visualization and pedagogical patterns.

Visualization

Since many people with ASD are visual thinkers and have focus on detail, visualization techniques like drawing diagrams or modifications of these have proved to be effective, both in explaining the tasks and splitting up tasks, as well as teaching the technique itself. When drawing diagrams whilst talking about the tasks to be solved, the student sees the connection between the diagrams /sketches, and the problem solving approach. The technique was further developed into a more structured form as part of a pedagogical pattern.

Pedagogical Patterns

Bergin developed fourteen patterns that formed the beginning approaches to a pattern language for Computer Science course development, but these patterns might have application to other fields as well. The “Early Bird” pattern states: *“Organize the course so that the most important topics are taught first. Teach the most important material, the “big ideas,” first (and often). When this seems impossible, teach the most important material as early as possible.”* (Bergin, J. 2000) Inspired by Bergin, patterns that address the most common challenges in the findings were created and tested on two students: understanding text, organizing work and addressing rigidity/stress. Understanding text in assignments and textbooks can be difficult. A suitable pattern for this problem is “Interpreter”. How to start work on a programming task and splitting the task into sub-tasks makes use of a pattern named “Smart assistant”. Helping the student relax and accept an alternative way of doing the work is called “Deep breath”.

A pattern consists of a pair: a defined problem and an appropriate solution. Patterns may begin with an abstract providing an overview of the pattern and indicating the types of problems it addresses. As in software design patterns, pedagogical patterns must have a good name which describes the problem. The contents of the pattern are:

1. (Abstract) – if necessary
2. Problem – describe the problem in detail
3. Audience/Context
4. Forces – describe the goal and the way there

5. Solution – identify the most important issues, describe solutions.
6. Pitfalls – what may go wrong or fail
7. Discussion – Describe consequences
8. Special resources – which tools and techniques does the instructor need
9. Examples and related patterns

Examples of the patterns “Smart assistant” and “Deep breath”

Pattern name: “Smart assistant”

Problem: The student is unable to structure the work. The approach to solving a mathematical problem or programming task is ad hoc.

Context: A compulsory assignment or exercise.

Forces: (Information for instructors) Students with ASD often get lost in detail and fail to see the big picture. It is helpful to relate to already familiar ideas and techniques. When approaching a complex situation outside student's normal experience, apply a model. The basis of the model needs to be known to the student.

Solution: Visualize with the help of diagrams. Organize the work by visualizing tasks and subtasks, addressing the most important material first. Check continuously to see if the student understands. Work together designing models like activity diagrams.

Pitfalls: The student may seem to understand and say “yes” when asked. It is important to let the student do the work independently, because deep understanding may not be in place.

Discussion/consequence: The student is very stressed by the issue and may not be able to communicate what the trouble is. Students with ASD experience stress and anxiety in unknown situations and with strangers. Too much information at once also causes stress, and will not always be understood. The instructor must know the limits of the models and communicate these to the students, so that they do not make improper inferences.

Special resources: Diagrams with which the student is familiar, for instance UML diagrams. Modifications of these. Simple informal sketches of boxes, arrows and circles Mindmaps.

Pattern name: “Deep breath”

Problem: The student has a rigid approach to organizing work. It may be the order of tasks or subtasks, or the order of organizing the day with lectures, exercises and individual work.

Context: An assignment needs to be completed. The day needs to be organized in a more structured way.

Forces: The students need to know where they stand and where they are heading, and understand that a different order yields the same or a better result and gets the work done.

Solution: Create a relaxing atmosphere. Identify and uncover the depth of the problem. Demonstrate alternative work-paths. Write pseudocode. Draw flow charts. Draw a list of tasks with arrows, and reverse the order.

Pitfalls: Sometimes, no amount of persuasion, plans or sketches will help. Be patient. Repeat the techniques.

Discussion/consequence: Plans are important. Rigid behaviour is common, and people with ASD need both day plans and work plans. Since obsession and rigid thinking is a big issue, it is necessary to think about how the problem can be generalized. Push mildly. The goal is to be able to hold a job and function in society.

Special resources: The instructor should make a plan showing the order of topics and how to introduce them. Subsets of topics and tasks can be designed by deciding on a minimal set of visualization tools to solve this and similar problems.

Discussion

Programs supporting students with disabilities are present at most institutions in higher education, but support for students with ASD varies in quality. Many programs address students with disabilities in general, and these are not suitable for students with ASD. From the findings in this study, two main groups of problems can be defined: pedagogical problems and practical/behaviour problems. Practical problems like extended deadlines and a quiet place for exams are commonly recommended. But with the introduction of digital exams, new problems arise. The examination rooms are in a different location, and this can cause anxiety. It takes time to get used to a new situation. In one case, parents have to drive the student to the location. The option of taking an exam in a secluded space/room at OsloMet creates problems, and is defined as a “private solution”, thus violating the principle of equal rights to education for all students.

The study shows that peer-mentoring is valuable and works well for many students. But a student mentor is not always able to communicate well enough, or does not have the necessary professional skills. One student reported that he was dissatisfied with the mentor who he felt did not have adequate academic skills. A second student who was ambitious was clear in his demand for a professionally strong candidate as mentor. Also, peer-mentoring does not suit all students, some prefer an adult to communicate with.

An informal inquiry showed that teachers are not aware that there are students with ASD on their courses. ASD is an invisible, cognitive disability, and unless instructors are informed (with the consent of the student), they will have no knowledge of the student’s presence. Instructors often do not know how to give appropriate professional support. Much frustration amongst instructors arises from guesswork and assumptions. Instructors need information and guidelines. Based on the findings in this study, pedagogical patterns have been developed and the effect has recently been studied on two students who were preparing for exams and had problems with study technique.

Not all people with ASD are visual thinkers, but all have an eye for detail, and the findings show that visualization techniques work well. Visualisation is also used in the patterns. In the study, diagrams like activity diagrams and workflows were created with pen and paper and digital tools. Visualisation can also be quite simple, drawing boxes or lists are good illustrations. It is not necessary to use digital tools or strict UML diagrams, improvisation works well. The informal approach creates a relaxed atmosphere where it is natural to talk about task solving while sketching. Looking at a sheet of paper also means not having eye-contact, which for some is stressful.

The pedagogical patterns expand on situations and background material, for instance focus on detail and not being able to see the big picture. Information and recommendations are given in the text so instructors can identify challenges and choose the appropriate pedagogical approach. Pitfalls and challenges are presented. Sometimes the student is very stressed and needs more time. Sometimes it is easy to change attitudes and behaviour, the student wishes to learn. But not all instructors have the patience, skills or interest in the subject. Questionable attitudes, prejudice and misinformation is not uncommon. Some instructors have their own views on what works, and these may be either ineffective or even harmful. That is why information and research-based practices are so important, as well as personal involvement of the teacher or peer-mentor. The students must feel secure.

The pattern “Smart Assistant” (with modifications) and “Deep breath” have recently been put to use in two cases, and feed-back from students and parents is positive. One student is currently making good progress with mandatory assignments after several

months of failure to produce work, another has succeeded in all three exams this semester. She expresses her thoughts after an exam:

“The exam went very well, I gave extensive answers to all the questions, and I think I got all the ER-diagrams and SQL-sentences right. I left with a very good feeling. Thank you so much for all your help with study technique, it meant so much.”

These patterns are developed for IT-students with ASD based on the findings in this study, but pedagogical patterns can be useful for supporting all students once their specific challenges have been identified, not only students with special needs. According to Nes et al., a sound principle in universal design of software solutions is to first target the user group with the greatest challenges (2008). Creating pedagogical patterns follows the same principle: design for the students with the greatest challenges. Inspiration from the patterns can be used by instructors to develop patterns that address learning problems, dyslexia or psychological problems as well as academic issues.

Conclusion and Further Work

The goal of all intervention for students with disabilities is to ensure participation in society and vocational life. Instructors must have knowledge of research that documents effective intervention for undergraduate students with ASD in order to develop suitable programs for this population. However, the literature describing the experiences of and programs for individuals with ASD in higher education is fragmented. This study has identified some common problems through interviews, observations and conversations with students and how to address these problems.

Rigid behaviour and compulsive thinking are common in people with ASD. When assisting students with ASD in problem-solving and interpretation of texts and assignments, visualization has proven to be more effective than lengthy verbal explanations. The findings indicate that visualization and modelling techniques that are well-known to the student can be an effective help, and show how pedagogical patterns can offer a template and a solution. Pedagogical patterns containing terminology and techniques from subjects in the curriculum (modelling, programming, mathematical formulas) have proven effective for improving study technique and learning strategies. Simple sketches with boxes and arrows can be used to explain how to tackle complicated tasks, and in this way, both the subject matter and the approach to problem solving can be conveyed to the student. Effect of the methods has been documented through feedback from students, parents and results of examinations.

Personal suitability of the instructors is crucial. An instructor or supervisor of students with ASD needs to have a great deal of tolerance and patience, as well as good communication skills. Teachers should in general be aware of the way they speak; clearly, without digressions and complex metaphors. This again benefits all students.

An interdisciplinary workshop at OsloMet will further develop pedagogical patterns targeting all students with special needs. Participants will be teachers and staff from administration, health studies and IT. A later study will determine the effectiveness of these patterns and their general practical use.

End note: This study has been reported to NSD.

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